Calibration of the Pitot SteamMeter

A. L. Carr
H. L. Strube

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THE CALIBRATION OF THE PITOT STEAM METER

A THESIS

PRESENTED BY

A. L. CARR
&
H. L. STRUBE

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H. F. Gebhardt
H. M. Raymond Dean of Eng. Studies

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Calibration of the Pitot Steam Meter

The object in view in this thesis work was to obtain experimental data for the calibration of a steam meter or instrument for measuring the flow of steam in a pipe. If possible, a scale was to be provided which would give the velocity of steam in feet per minute or the quantity in pounds per hour, so that the instrument might be set up on any size steam pipe and those quantities be observed at a glance. The constant of the pitot tube was to be determined by calculating the ratio of the actual velocity in the pipe to the theoretical velocity.

In order to determine the practicability of the instrument, tests were made on pipes varying in size from one inch to three inches in diameter and with velocities varying from 500 to 10000 feet per minute; also with pressures varying from 60 to 90 pounds gauge.

The principle upon which the instrument is based is that of the well-known Pitot tube. Refering to the accompanying sketch, the Pitot Steam Velocity meter may be described as follows:- The meter consists of two parallel tubes each a little over two feet in length and connected at the extremities by hollow castings. One of the tubes is an ordinary gauge glass which has been surrounded

by a metalic sleeve having graduated upon it a scale divided into inches and tenths of inches up to 25 inches. The other is an ordinary one half inch pipe and is called the pressure tube. The tubes are meant to be mounted vertically in order to give correct readings of the scale. It is seen that a small tube called the Pitot tube extends from the lower opening. It is about 3/32-inch internal diameter and is meant to project into the pipe so that its end is in the center of the steam pipe. The opening of this tube is made to face at right angles to the flow of steam in the pipe. The other end of the pitot tube is screwed into a diaphraghm made into the hollow casting which prevents steam from entering the lower opening of the gauge glass except through the pitot tube itself. This diaphragm is set back far enough in the casting to allow the steam entering the 1/2 inch pipe and surrounding the pitot tube, to flow up the pressure tube and over into the top of the gauge glass. In flowing up this tube and entering the gauge glass the steam is condensed and gravitates down the glass to form a head of water.

Since the pitot tube allows both pressure and velocity heads to be exerted at the lower opening of the gauge glass while only a pressure head is exerted from above, it is evident that the two pressures will exactly neutralize each other leaving only the velocity head.

This velocity head is then determined from the height of water or condensed steam in the glass, by the well known hydraulic formula $V=\sqrt{2gh}$ when

h = head in feet of steam

g = gravity

v = velocity in feet per second

This formula is not exactly correct for a gas or a vapor, as steam, but is sufficiently correct for all practical purposes and may be used here. The head in inches of water may easily be converted to feet of steam by multiplying the height by the ratio of the density of water to steam at the given temperature and pressure in the pipe.

The flow of steam through the meter is controlled by means of the angle valves.

The instrument is attached to a pipe by means of a union and 1/2 inch nipple, the latter screwing into a hole tapped into the pipe directly or into a fitting. The end of this nipple is meant to come flush with the internal surface of the steam pipe so as to preclude the possibility of eddy currents, etc, from creating a false pressure. The head of water in the gauge glass is balanced by the velocity head because of the impulse of the moving steam, the latter striking the opening of the pitot tube.

The arrangement of the apparatus is shown in Fig. 2. Steam was allowed to flow through the pipe to be tested and was condensed in a surface condenser; from which it was discharged into weighing tanks. From the known area of the pipe and the known quantity of steam the actual velocity of the steam flowing through the pipe may be obtained. The quantity of steam is obtained from the weight of water by multiplying the latter by the volume of one pound of steam at the known pressure. Thus the actual velocity in feet per minute is equal to ---- weight of water per minute X specific volume of steam at the pressure divided by the area of the pipe in square ft. The theoretical velocity is obtained approximately from the formula $V = \sqrt{2gh}$

The ratio of the actual to the theoretical velocity will give the constant of the tube. It should be unity, provided the pressure part of the instrument is designed properly.

Referring to Fig. 2 it is seen that the upper valve control~~l~~s the pressure of the steam flowing through the pipe to be tested while the lower one control~~l~~s the velocity. In starting a run both these valves are opened to allow steam to flow through to the condenser. Both the angle valves on the meter itself are previously closed. Then the upper angle valve is opened slightly at first to

allow the gauge glass to gradually become heated. After this valve has been opened wide, the steam is allowed to condense in the ~~open~~ upper casting and fill the gauge glass. The lower angle valve is then opened and this condensed steam allowed to adjust itself to the prop~~p~~er head corresponding to the velocity of the steam flowing through the pipe. Runs of five minutes were taken and readings of the instrument made every minute, care being taken to keep the pressure constant. This is essential, as any change in pressure will cause a change in head which will be proportional to the square of the velocity. In most of the later experiments five different velocities were obtained for each pressure in order that five points be obtained for curves to be plotted with meter readings and velocities in feet per minute as coordinates.

The first series of experiments were made on a three-inch pipe. The connecting nipple was in this case screwed into a hole tapped in the pipe. The meter was set at an angle of about 12 1/2 degrees with the horizontal and a run made with constant pressure, but with velocity heads varying the length of the tube. This angle of 12 1/2 degrees gave a maximum vertical head of 6 1/2 inches of water. The object of tipping the instrument at an angle was to obtain readings which would be more sensitive

to any change of velocity for low velocities. The range in velocity is not as great as when vertical, but it is enough for all practical purposes. A new instrument in being made with a slant of about 12 degrees which will have a scale reading the actual vertical head of water. Referring to the data obtained (see blue print Apr. 18) it will be seen that the maximum velocity obtained with the instrument at 12 1/2 degrees to the horizontal, was over 5000 feet per minute which is greater than any velocity obtained in practice.

Next a series of runs were made upon a one inch pipe in which the connecting nipple was screwed into the 1/2 inch opening of a 1x1x1/2 inch tee. We were unsuccessful in securing reliable results in this case, because the pressure head was evidently affected by the opening to the pressure tube. A considerable cavity is left at the opening to the pressure tube inside the tee which causes the steam to swirl and eddy at this point thereby effecting the readings of the meter by unbalancing the pressure heads. A special fitting was therefore made which did away with this defect. A number of runs were taken with this fitting and the constant of the pitot tube averaged about 0.794. In figuring this constant all the constants were averaged (for different velocities). It is thought that

those obtained for low velocities were incorrect because they differ from the others by so great an amount. If these are left out the constant will become 0.82.

When attached to a 2-inch pipe the constant of the meter was calculated to average about 0.88. The connecting nipple was screwed into a 1/2-inch hole tapped into the pipe the same as with the 3-inch pipe. The results obtained are believed to be reliable because all conditions were as nearly constant as it was possible to make them. However as in the case of a one inch pipe ,the lower velocity readings appear to be unreliable.

With a 2 1/2-inch pipe the nipple attachment was screwed into the 1/2 inch opening of a 2 1/2 X 1/2-inch cross fitting. The same trouble was encountered with this fitting as with the one inch tee, namely, that eddy currents affected the pressure head to such an extent as to spoil the readings of the meter. The constant of the tube figures out to be only 0.54, which is ~~only~~ evidently incorrect. These results will not be found with the other data as they are believed to be incorrect.

The 2 1/2-inch pipe carried steam to a cross-compound engine, so the behavior of the instrument,when attached to a pipe through which steam was flowing to a running engine,was observed. The column of condensed steam did not fluctuate any more when the engine was run-

ning than when the steam was being blown through the pipe, thus proving that this instrument may be successfully used to measure the flow of steam in a pipe leading to a running engine or turbine.

Runs were next taken on a 3-inch pipe during which the instrument was kept in a vertical position. It was impossible to get more than a 5-inch head of water because of the large size of pipe requiring a great quantity of steam. However it will be seen that the constant of the tube is nearly unity for the results obtained. The average constant for the 3-inch pipe is 0.95. This quantity was lowered by two runs which were probably incorrect viz., those giving constants of 0.862 and 0.835 ; with these two results left out the average constant would be 0.98 which is as near unity as the accuracy of experimental work would allow.

It will be noticed that as the size of pipe increased, the size of the constant also increased. Altho' the opening of the pitot tube was at the center of the steam pipe in each case, it is probable that with the smaller size pipes, the swirling of the steam in the pipe effected the readings. Then again it may be due to the pitot tubes themselves since different tubes were used for each size of pipe. Had time permitted we would have

determined the effect of shifting the pitot tube across the diameter of the pipe and found the best position in which to leave the tube while making a run. Therefore it was thought best to place the opening of the tube in the center of the pipe which is not necessarily the mean velocity center or radius. The quality of steam and the pressure also affects effects the readings of the instrument. By the time the steam reached the meter in our apparatus it contained considerable moisture, although every means outside of a separator were used to lower the percentage. No determinations of quality were made.

The accompanying curves show the relation between the meter readings and the velocity of steam in feet per minute; also the weights of steam in pounds per hour and meter readings. The best curves were obtained with the 2 inch pipe and show the relation between the actual and the theoretical values of velocity. As previously stated the range in heads is not great enough with the 3 inch pipe to give valuable curves. The results would probably be more nearly correct had the tube been tilted as it was in the first case.

An example of the method of calculating results is shown below;

(From data obtained on June 1)

pressure of steam = 88 pounds absolute

specific volume of steam at 88# = 4.96 cu. ft.

Temp. of steam at 88# = 325 degrees F.

weight of one cu. ft. of water at 325 degrees = 56.65

weight of one cu. ft. of steam at 88# = 0.201

average meter reading for 5 minutes run = 5.5

weight of steam flowing thru pipe in 5 minutes = 249#

area of three inch pipe = 0.0491 sq. ft.

Therefore actual velocity of steam $\frac{249 \times 4.96}{5 \times 0.0491} = 5030$ ft min.

Theoretical velocity of steam $V=\sqrt{2gh}$ approximately

$$= 8.025 \times 60 \sqrt{5.5 \times \frac{56.65}{12 \times .201}} = 5470 \text{ ft.per minute}$$

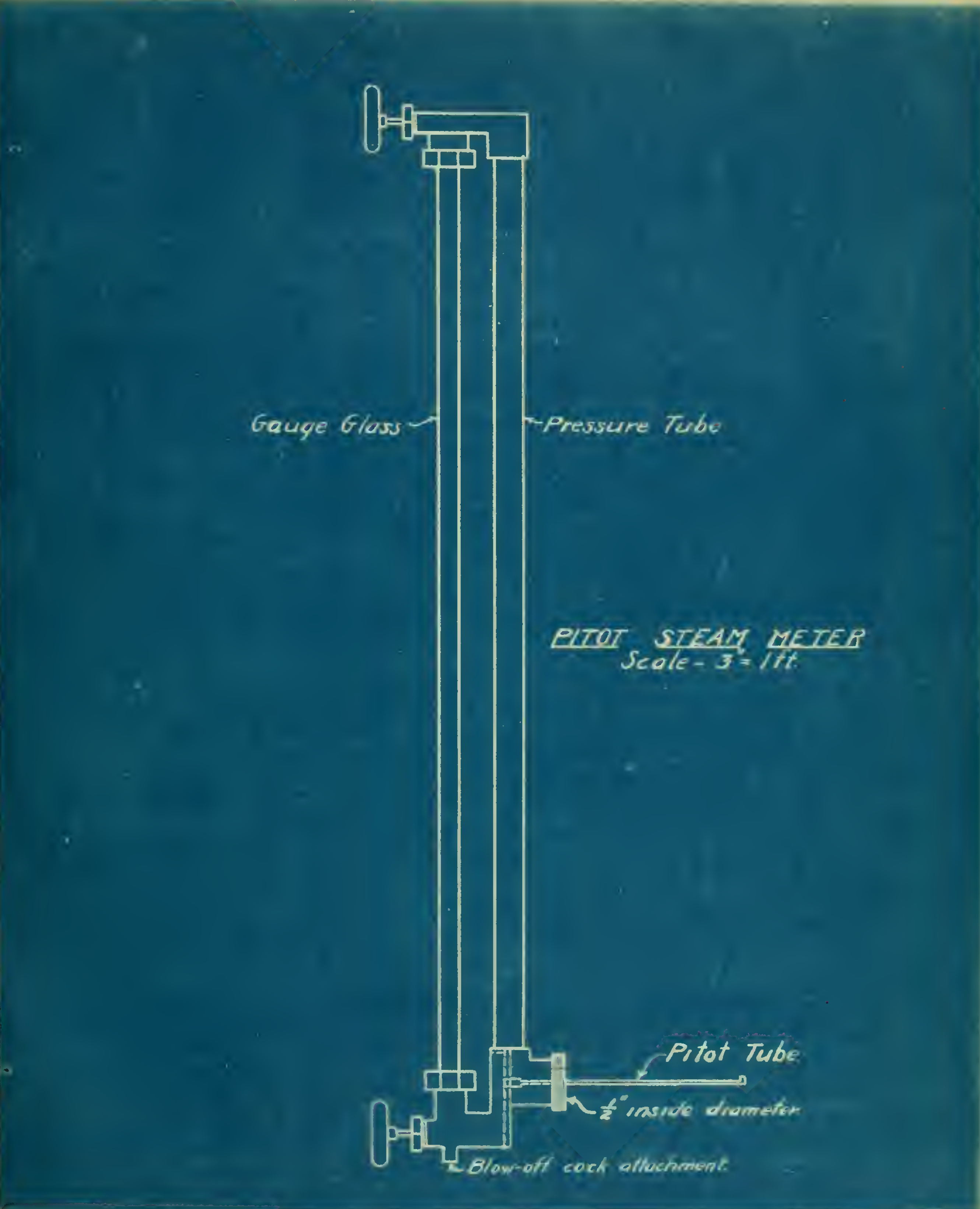
Therefore the constant of the pitot tube is $\frac{5030}{5470} = .921$

The results of the tests on this pitot steam meter show that it may be used successfully in practice for the measurement of the flow of steam in a pipe. It was shown that the instrument could be easily and quickly attached to any steam pipe and for high velocities the results obtained were fairly constant. The new instrument which was designed for lower velocities such as those of steam flowing to a running engine, e.g. 2000 feet per min., will undoubtedly give better results for these lower velocities. The head of water for the instrument is very sensitive to any change in pressure or velocity in the steam

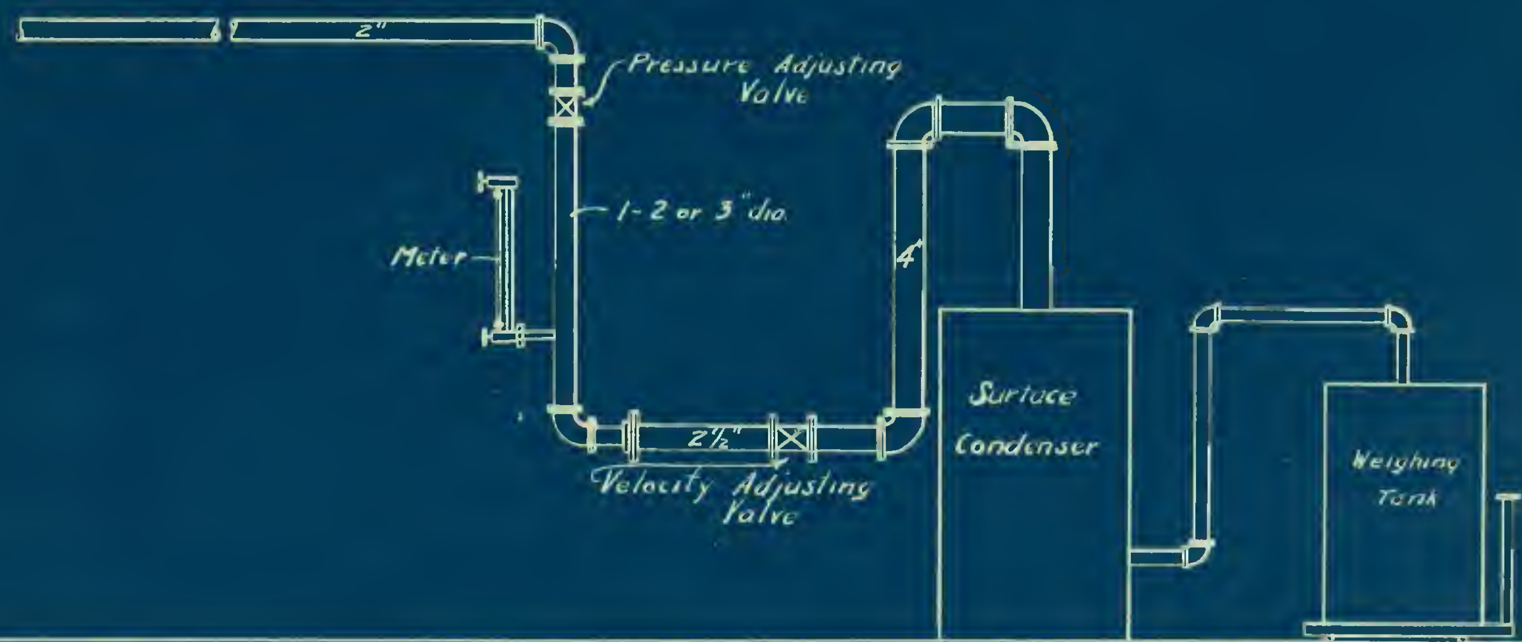
pipe and for this reason would be very valuable in practice, especially for use in tests. An idea of the actual amount of steam consumed by an engine may be obtained which might result in greater economy being practiced by the engineer in charge.

While the tests were necessarily cut short, still enough data was obtained to give an idea of the practicability of the instrument.

R. L. Carr
H. L. Strube



Gauge Glass
Pressure Tube
PITOT STEAM METER
Scale - 3" = 1 ft.
Pitot Tube
½" inside diameter
Blow-off cock attachment



2"
Pressure Adjusting Valve
1-2 or 3" dia.
Meter
4"
2½"
Velocity Adjusting Valve
Surface Condenser
Weighing Tank

Fig. 2.

May 14 1906 — 1" Pipe

Time	Pressure #/□" Abs.	Meter Readings	Wts. of Water	Actual Vel. - ft/min.	Theor. Vel. - ft/min.	Constant
4:16	84	6.1	529			
17	do	5.8				
18	do.	5.9				
19	do	5.8		4560	5730	0.796
20	do	5.9				
21	do	5.8	553			
4:29	84	7.2	553			
30	83.5	7.2				
31	do	7.0		4980	6300	0.79
32	83	6.95				
33	do	7.0				
34	do	6.95	579			
4:40	84	1.6	579.5			
41	do	1.6				
42	do	1.6		2510	2940	0.855
43	do	1.65				
44	do	1.6				
45	do	1.65	592.5			

May 14. (cont'd)				1" Pipe		
Time	Abs Pressure	Meter Readings	Wts. of Water	Actual Velocity	Theo. Velocity	Constant
4:59	84	3.3	592			
5:00	do	3.3				
.01	do	3.3		3895	4275	0.91
02	do	3.3				
03	do	3.4				
04	do	3.3	612.5			
May 15. 1906				1" Pipe		
10:09	100.7	23.4	859			
10	do	22.8				
11	do	22.9		8175	10380	0.788
12	do	22.6				
13	do	22.5				
14	do	23.0	910.5			
10:16	100.7	17.8	910.5			
17	do	17.9				
18	do	18.1		7210	9190	0.785
19	do	18.3				
20	do	17.9				
21	do	17.5	956			

May 15, 1906 (cont'd) 1" pipe

Time	Pressure	Meter Reading	Wts of Water	Actual Vel.	Theo Vel	Constant
10:23	100.7	9.25	956			
24	do	9.35				
25	do	9.4		5150	6650	0.775
26	do	9.3				
27	do	9.6				
28	do	9.4	988.5			
10:31	100.7	4.7	988.5			
32	do	4.9				
33	do	4.6		3644	4630	0.788
34	do	4.6				
35	do	40				
36	do	4.1	1011.5			
10:39	100.7	1.4	1011.5			
40	do	1.4				
41	do	1.5		2538	2605	0.974
42	do	1.4				
43	do	1.4				
44	do	1.4	1027.5			

May 15, 1906 1" Pipe

Time	Pressure	Meter Readings	Wts. of Water	Actual Vel	Theo. Vel.	Constant
11:09	95.2	11.1	1027.5			
10	do	11.1				
11	do	11.1		6430	7440	0.865
12	do	11.2				
13	do	11.2				
14	do	11.2	1066			
11:21	95.2	20.6	1066.5			
22	do	20.6				
23	do	20.6		7940	10110	0.785
24	do	20.5				
25	do	20.6				
26	do	20.6	1114			
11.27	95.2	6.2	1114			
28	do	6.1				
29	do	6.15		4310	5595	0.806
30	do	6.15				
31	do	6.1				
32	do	6.2	1141			

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel.	Theo. Vel.	Constant of Tube
	May 15. (Cont'd)				1" Pipe.	
11:34	45.2	2.4	1141			
35	do	2.4				
36	do	2.4		2840	3480	0.816
37	do	2.45				
38	do	2.45				
39	do	2.5	1158			
	May 18, 1906				1" Pipe	
1:54	104.2	20.1	554			
55	103.2	20.5				
56	103.2	20.7		6465	9690	0.667
57	104.2	20.4				
58	104.2	20.5				
59	104.2	19.6	595.5			
2:30	104.2	13.0	628.5			
31	103.2	13.1				
32	103.2	12.9		5600	7650	0.732
33	104.2	12.9				
34	104.2	12.0				
35	104.2	11.8	664.5			

May 18, 1906 (cont'd) 1" Pipe

Time	Abs. Pressure.	Meter Reading	Wts. of Water	Actual Vel.	Theo. Vel.	Constant of Tube
2:36	104.2	7.8	664.5			
37	do	7.6				
38	do	7.5		4660	5940	0.785
39	do	7.6				
40	do	7.6				
41	do	7.6	694.5			
2:44	104.2	2.7	694.5			
45	do	2.8				
46	do	2.8		2485	3740	0.665
47	do	3.4				
48	do	3.7				
49	do	2.9	710.5			
2:51	104.2	1.2	710.5			
52	do	1.2				
53	do	1.1		1242	2255	0.552
54	do	1.0				
55	do	1.0				
56	do	1.1	718.5			

May 22, 1906 1" Pipe.

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel.	Theo. Vel.	Constant of Tube.
9:43	96.7	23.4	542.5			
44	98.7	23.5				
45	do	23.8		9950	10800	0.921
46	do	24.2				
47	do	24.2				
			591			
9:50	98.7	17.3	591			
51	do	17.2				
52	do	17.2		6860	9100	0.755
53	do	16.9				
54	do	17.2				
55	do	17.2	633			
9:58	98.7	13.9	633			
59	do	14.0				
10:01	do	13.9		6210	8200	0.758
02	do	14.3				
03	do	13.6				
04	do	13.3	671			

May 22. (cont'd) 1" Pipe

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel	Constant
10:25	98.7	5.5	532.5			
26	do	5.5				
27	do	5.5		3600	5150	0.70
28	do	5.4				
29	do	5.3				
30	97.7	5.5	554.5			
10:38	98.7	1.8	554.5			
39	do	1.1				
40	do	1.1		1227	2570	0.478
41	do	1.1				
42	do	1.1				
43	do	1.7	562			
11:31	94.7	3.7	531			
32	do	4.2				
33	do	3.7		3735	4440	0.881
34	do	4.4				
35	do	4.8				
36	do	3.1	553			

May 22, 1906 (cont'd) 1" Pipe.

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel	Constant
11:41	94.7	9.4	553			
42	do	10.0				
43	do	10.1		5440	7050	0.772
44	do	9.7				
45	do	9.9				
46	do	9.9	58.5			
11:50	94.7	14.2	585			
51	do	14.3				
52	do	14.5		6880	8640	0.797
53	do	14.7				
54	do	15.1				
55	do	15.4	625.5			
2:27	94.7	17.8	574.5			
28	do	17.8				
29	do	17.7		7555	9450	0.80
30	do	17.7				
31	do	17.5				
32	do	17.4	619			

May 22 1906 (cont'd) 1" Pipe

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel.	Theo. Vel.	Tube Constant
2:43	94.7	23.8	624			
44	do	24.2				
45	do	24.0		9000	11000	0.818
46	do	23.8				
47	do	24.0				
48	do	23.9	677			
3:03	89.7	22.1	526.5			
04	do	21.4				
05	do	21.3		8755	10700	0.818
06	do	21.1				
07	do	21.2				
08	do	21.2	575.5			
3:09	89.7	15.5	575.5			
10	do	15.6				
11	do	15.5		7600	9140	0.832
12	do	15.6				
13	do	15.6				
14	do	15.7	618			

May 22. (cont'd) 1" pipe.

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel	Constant
3:16	89.7	9.7	618			
17	do	9.9				
18	do	10.0		6165	7290	0.846
19	do	10.0				
20	do	9.9				
21	do	10.1	652.5			
3:26	89.7	5.7	533			
27	do	5.4				
28	do	5.5		4825	5450	0.886
29	do	5.5				
30	do	5.7				
31	do	5.5	560			
3:35	89.7	1.1	560			
36	do	1.2				
37	do	1.2		2502	2675	0.94
38	do	1.5				
39	do	1.3				
	do	1.4	574			

May 22 (cont'd) 1" Pipe

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel.	Theo. Vel.	Constant
3:42	84.7	1.2	574			
43	do	1.1				
44	do	1.2		2637	2680	0.984
45	do	1.4				
46	do	1.4				
47	do	1.3	588			
3:53	84.7	6.2	588			
54	do	6.5				
55	do	6.0		5080	5880	0.865
56	do	5.9				
57	do	6.2				
58	do	5.9	615			
4:01	84.7	10.8	615			
02	do	11.0				
03	do	11.8		6680	8080	0.827
04	do	11.9				
05	do	12.0				
06	do	11.8	650.5			

May 22 (cont'd)　　　　1" Pipe

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel.	Theo. Vel.	Constant
4:10	84.7	16.9	552.5			
11	do	16.9				
12	do	17.2		8850	9870	0.896
13	do	17.4				
14	do	17.6				
15	do	17.4	599.5			
4:20	84.7	23.7	599.5			
21	do	24.0				
22	do	23.2		9700	11590	0.837
23	do	23.8				
24	do	24.2				
25	do	23.6	651			

May 25 1906 — 2" Pipe

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel.	Theo. Vel.	Constant
1:25	103.2	19.9	523.5			
26	do	19.0				
27	do	18.4		6975	9200	0.758
28	do	18.0				
29	do	17.7				
30	do	16.6	701.5			
1:35	102.2	21.5	701.5			
36	101.7	21.3				
37	100.7	21.1		8610	10000	0.861
38	101.2	21.1				
39	102.2	20.5				
40	103.2	21.0	918.5			
1.43	103.2	10.3	918.5			
44	do	10.3				
45	do	10.4		6110	6940	0.88
46	do	10.4				
47	do	10.5				
48	do	10.4	1074.5			

May 25, (cont'd)

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel.	Theo. Vel.	Constant.
1:50	103.2	5.0	1074.5			
51	do	5.1				
52	do	do		4190	4855	0.862
53	do	do				
54	do	do				
55	do	do	1181.5			
1:58	103.2	1.1	545			
59	do	1.05				
2:00	do	1.0		2155	2187	0.985
2:01	do	0.95				
2:02	do	1.05				
2:03	do	1.05	600			
2:14	97.7	1.15	600			
15	do	1.0				
16	do	1.05		2285	2270	1.006
17	do	1.0				
18	do	1.1				
19	do	1.0	655.5			

May 25 (cont'd)

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel	Theo. Vel.	Constant
2:24	97.7	5.0	655.5			
25	do	5.1				
26	do	5.15		4495	5005	0.897
27	do	5.15				
28	do	5.15				
29	do	5.1	764.5			
2:38	97.7	12.7	764			
39	do	12.6				
40	do	12.7		7025	7895	0.89
41	do	12.6				
42	do	12.7				
43	do	12.8	934.5			
2:54	97.7	17.6	934.5			
55	do	17.4				
56	do	17.5		8100	9270	0.875
57	do	17.6				
58	do	17.55				
59	do	do	1131			

May 25 (cont'd)

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel.	Constant
3:07	93.2	15.5	541.5			
08	do	15.5				
09	do	15.45		7680	8900	0.863
10	do	15.4				
11	do	15.35				
12	do	15.5	719.5			
3:14	93.2	9.65	719.5			
15	do	9.6				
16	do	9.7		6210	7050	0.884
17	do	9.7				
18	do	9.7				
19	do	9.65	863.5			
3:21	93.2	5.05	863.5			
22	do	5.1				
23	do	do		4645	5120	0.906
24	do	do				
25	do	do				
26	do	do	971			

May 25 (cont'd)

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel.	Theo. Vel.	Constant.
3:27	93.2	1.25	971			
28	do	1.3				
29	do	1.25		2720	2540	1.07
30	do	do				
31	do	do				
32	do	do	1034			
3:35	88.2	0.45	1034			
36	do	0.35				
37	do	do		1722	1440	1.197
38	do	do				
39	do	0.4				
40	do	do	1072			
3:48	88.2	4.95	1071.5			
49	do	4.95				
50	do	4.85		4400	5170	0.851
51	do	do				
52	do	4.9				
53	do	do	1168.5			

May 25 (cont'd)

Time	Abs. Pressure	Meter Reading	Wts of Water	Actual Vel.	Theo. Vel.	Constant.
3:59	88.2	9.95	539.5			
4:00	do	9.9				
01	do	9.4		6440	7240	0.89
02	do	9.4				
03	do	9:35				
04	do	9.9	681.5			
4:11	88.2	16.65	681			
12	do	16.6				
13	do	16.5		8140	9475	0.86
14	do	16.45				
15	do	16.55				
16	do	16.6	860.5			
4:25	83.2	18.0	860.5			
26	do	do				
27	do	17.9		8770	10160	0.894
28	do	18.1				
29	do	17.95				
30	do	18.05	1043.5			

May 25. (cont'd) 2" Pipe

Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel.	Constant
4:35	83.2	9.3	1043.5			
36	do	9.45				
37	do	9.4		6590	7340	0.898
38	do	9.4				
39	do	9.35				
40	do	9.4	1181			
4:43	83.2	5.0	743			
44	do	5.1				
45	do	5.1		4890	5410	0.904
46	do	5.2				
47	do	5.1				
48	do	5.1	845			
4:50	83.2	1.45	845			
51	do	1.5				
52	do	1.65		3042	3075	0.99
53	do	1.85				
54	do	1.6				
55	do	1.85	908.5			

June 1, (cont'd) 3" Pipe.

Time	Abs. Pressure	Meter Readings	Wts of Water	Actual Vel.	Theo. Vel.	Constant.
10:35	101.7	4.9	558			
36	do	4.8				
37	do	4.5		3730	4470	0.835
38	do	4.4				
39	do	4.0				
40	do	3.5	770			
10:42	101.7	1.9	770			
43	do	1.9				
44	do	2.0		3165	2960	1.07
45	do	1.95				
46	do	2.05				
47	do	2.0	950			
10:50	97	3.8	531			
51	do	4.0				
52	do	4.3		4150	4560	0.91
53	do	4.5				
54	do	4.8				
55	do	4.6	756			

June 1. (cont'd) 3" Pipe

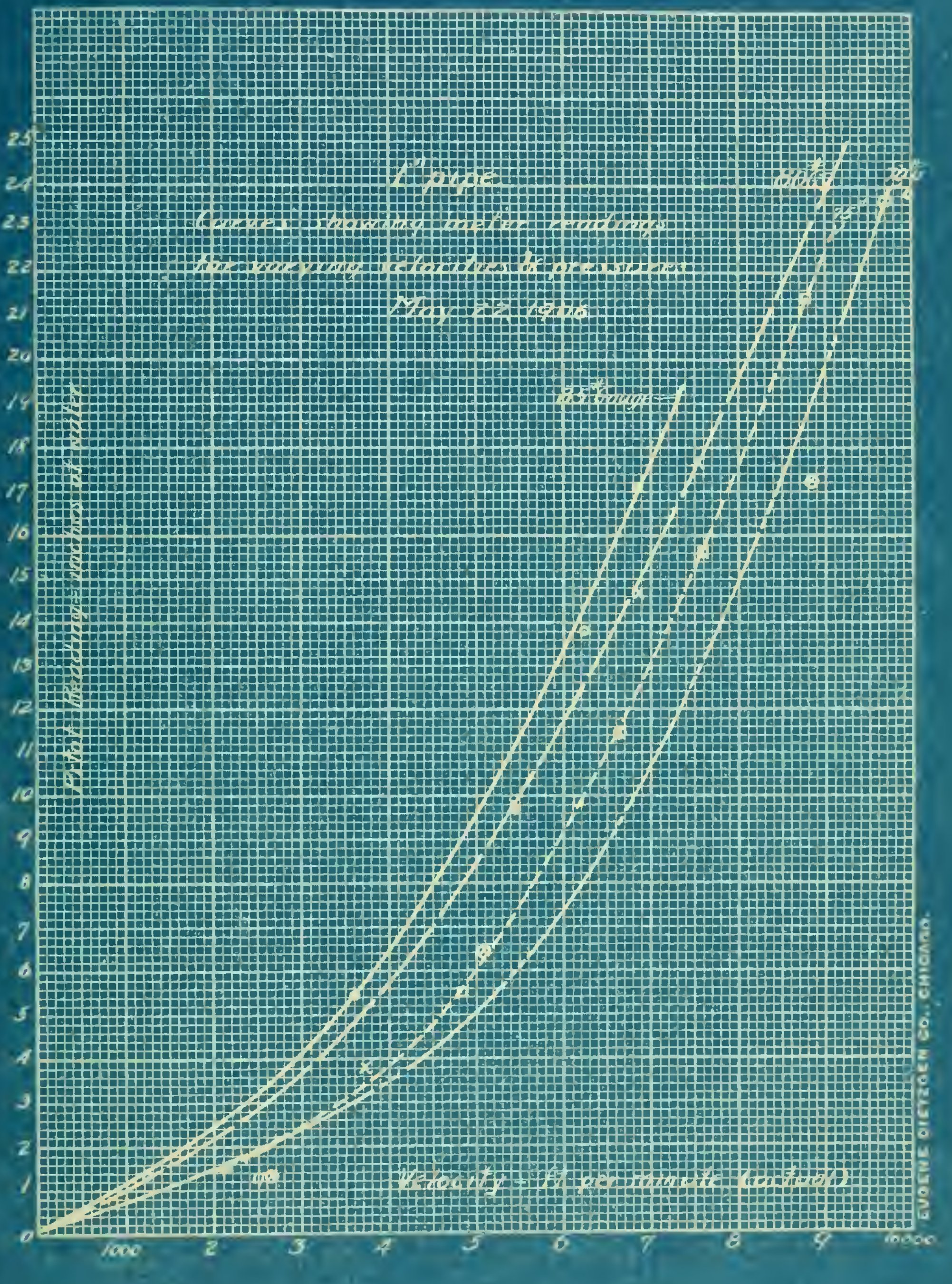
Time	Abs. Pressure	Meter Reading	Wts. of Water	Actual Vel	Theo. Vel.	Constant
10:57	97	3.4	756			
58	do	3.5				
59	do	3.9		3600	4225	0.862
11:00	do	3.9				
01	do	3.8				
02	do	3.9	951			
11:10	97	1.4	543			
11	do	do				
12	do	do		2785	2625	1.06
13	do	do				
14	do	do				
15	do	do	694			
11:23	97	2.3	694			
24	do	2.35				
25	do	2.45		3190	3320	0.963
26	do	2.0				
27	do	2.1				
28	do	2.2	867			

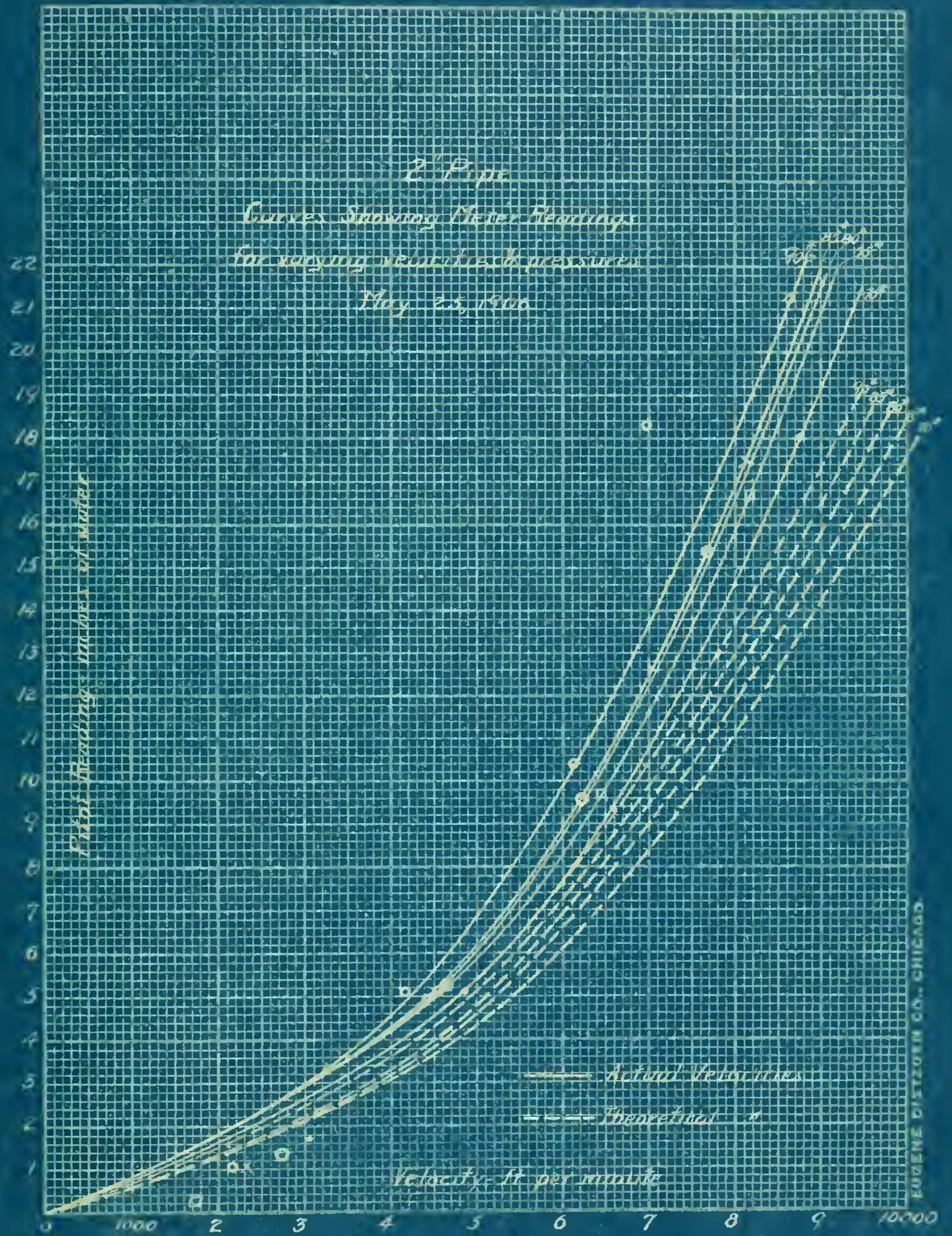
June 1, 1906 3" Pipe

Time	Abs. Pressure	Meter Reading	Wts of Water	Actual Vel.	Theo. Vel.	Constant
1:33	88	5.2	530			
34	do	5.5				
35	do	5.7		5030	5470	0.921
36	do	5.6				
37	do	5.4				
38	do	5.6	779			
1:40	88	4.5	779			
41	do	4.8				
42	do	4.6		4660	4875	0.956
43	do	4.2				
44	do	4.1				
45	do	4.2	1010			
1:50	88	2.9	554.5			
51	do	2.7				
52	do	2.7		3800	3885	0.98
53	do	2.8				
54	do	2.8				
55	do	2.7	742.5			

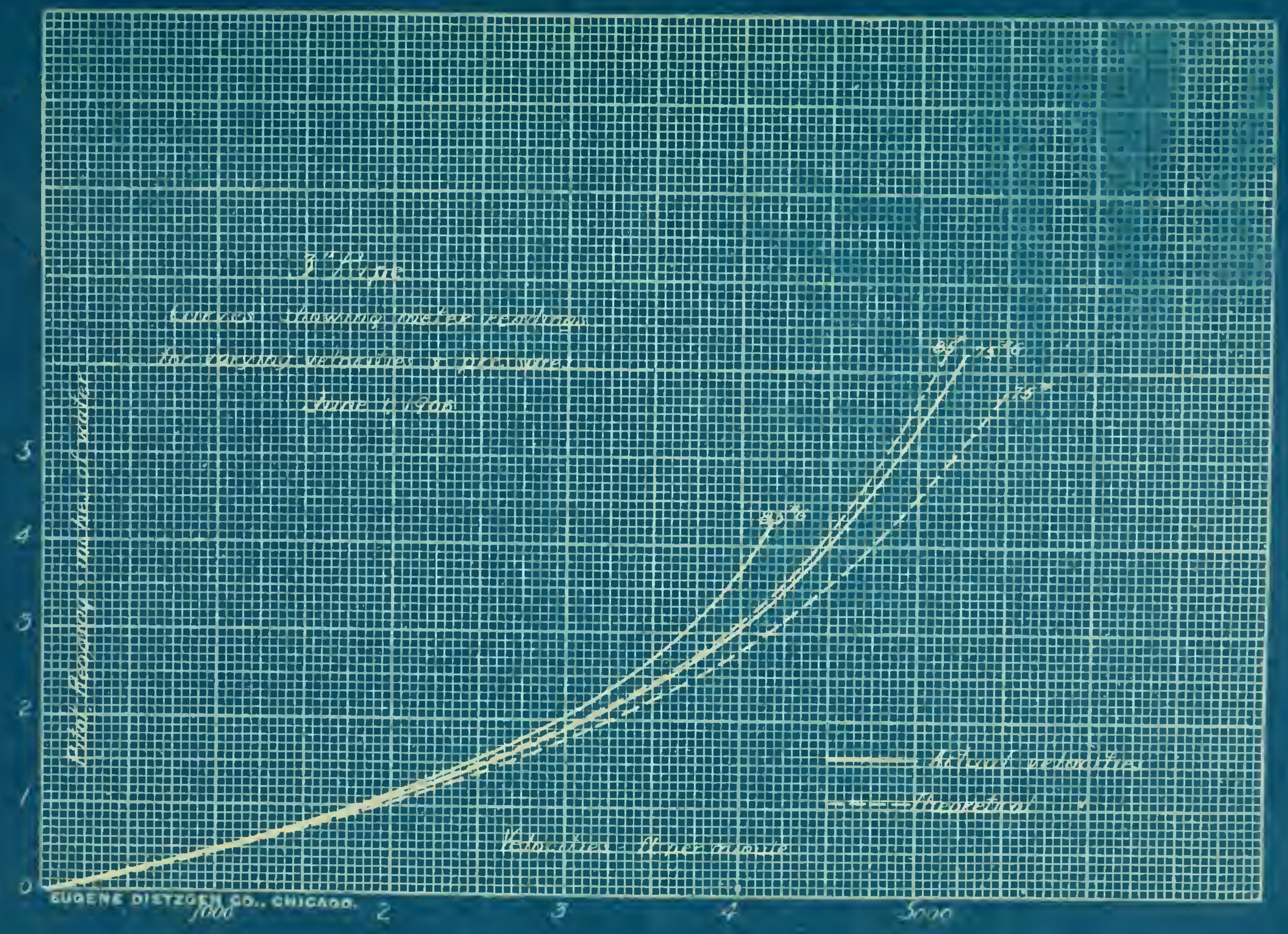
June 1 (cont'd) 3" Pipe

Time	Abs. Pressure	Meter Readings	Wts. of Water	Actual Vel.	Theo. Vel.	Constant
2:00	88	1.7	742.5			
01	do	1.75				
02	do	1.8		3070	3230	0.95
03	do	1.9				
04	do	2.3				
05	do	2.0	894.5			
					Average Constants	
					1" Pipe	0.80
					2" "	0.88
					3" "	0.95

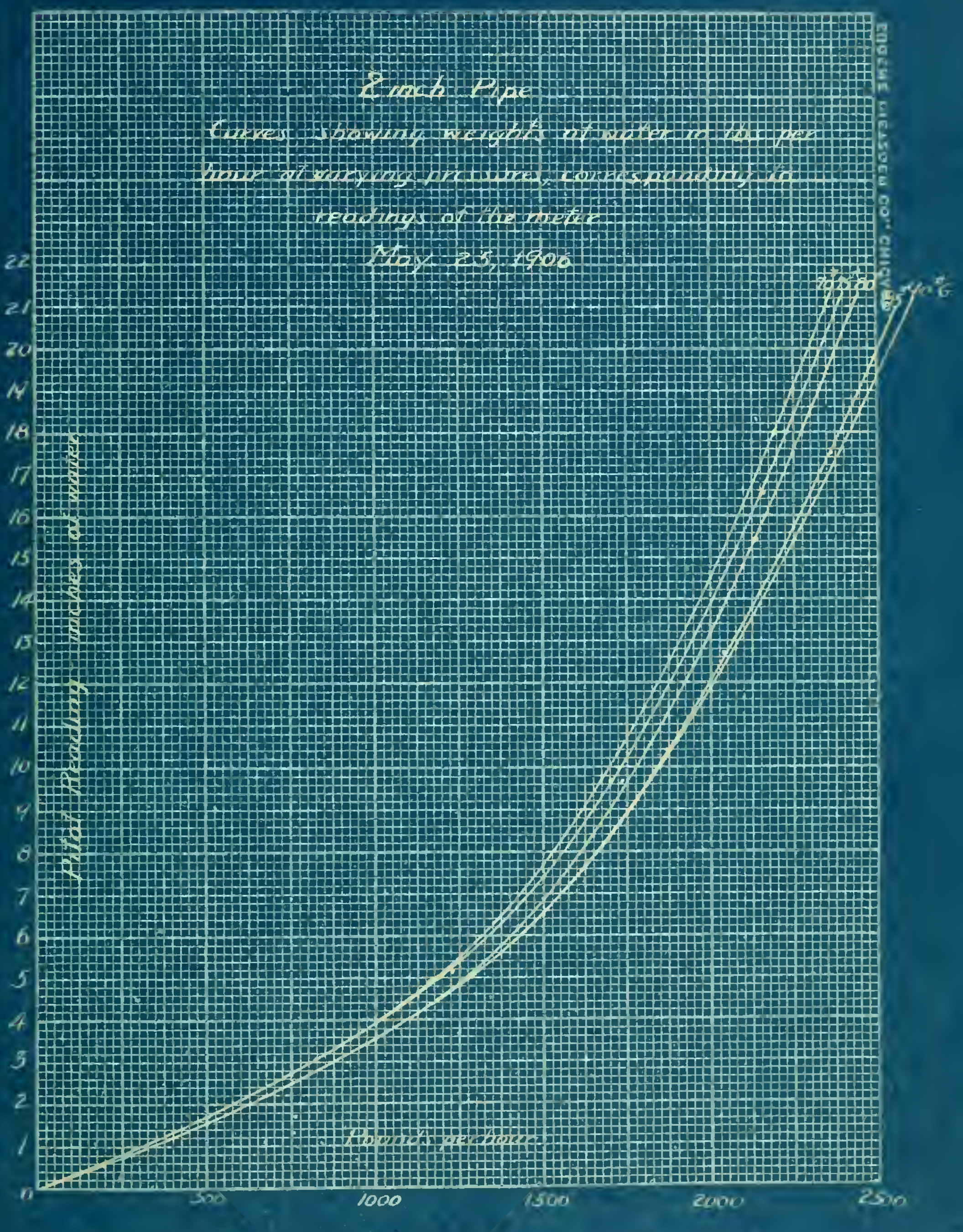

1" pipe
Curves showing meter readings
for varying velocities & pressures
May 22 1906
Velocity – ft per minute (actual)
0
1000
2
3
4
5
6
7
8
9
10000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
EUGENE DIETZGEN CO., CHICAGO.



2" Pipe
Curves Showing Meter Readings
for varying velocities & pressures
May 25, 1900
Actual Velocities
Theoretical "
Velocity ft per minute
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
1000
2
3
4
5
6
7
8
9
10000
EUGENE DIETZGEN CO., CHICAGO



3" Pipe
Curves showing meter readings
for varying velocities & pressures
Pitot Reading - inches of water
Velocities - ft per minute
Actual velocities
Theoretical
0
1
2
3
4
5
1000
2
3
4
5000
EUGENE DIETZGEN CO., CHICAGO.


2 inch Pipe
Curves showing weights of water in lbs per hour at varying pressures, corresponding to readings of the meter
May 25, 1906
Pitot Reading inches of water
Pounds per hour
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
500
1000
1500
2000
2500
40°C
EUGENE DIETZGEN CO. CHICAGO